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CORRELATION BETWEEN EGG-LAYING ACTIVITY AND YELLOW PIGMENT IN THE DOMESTIC FOWL¹

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So far as the presence of visible yellow pigment is concerned, there are two groups of domestic fowls. In the first group, represented by the Orpington breed, yellow is constantly absent from legs, beak and body fat. In the second group, represented by the Leghorns and the so-called American breeds, such as the Plymouth Rocks, Wyandottes and Rhode Island Reds, yellow, in the form of yellow fat,² is present in varying amounts in the parts mentioned. In this latter group, individual birds may undergo considerable change in the amount of the yellow pigment visible. The standard of the show-room, however, demands yellow in the legs and beak in these breeds and, in consequence, birds that have become pale in these parts are liable to be scored down by the professional poultry judge. The paling or yellowing of the legs in the breeds mentioned has been attributed by poultrymen to various environmental factors. Thus, good health and vitality, abundance of range and exercise, proper food such as meat, corn, gluten meal and "green food" are said to increase the amount of yellow pigment, while poor health, moulting, confinement with insufficient exercise, running on sandy soil and in mud, as well as climate and the mere aging of the bird, are held to be responsible for the paling of the legs in these varieties.

Of recent years, some individual poultrymen have claimed that paling of the legs is due to heavy laying. This view has been maintained by J. E. Rice.³ Mr. Tom Barron,⁴ one of the most successful of the English poultrymen, in an address before the Connecticut Poultry

¹ Paper presented in brief before the American Society of Naturalists, Philadelphia, December 31, 1914.

² Barrows, H R., "Histological Basis of Shank Colors in Domestic Fowl," Bull. 232, Maine Agric. Exper. Station, 1914.

³ Circular 54, N. Y. State Dept. of Agriculture, 1912.

⁴ *Connecticut Farmer*, September 12, 1914.

Convention, July, 1914, described his use of the color of the legs in selecting high egg-producers. Moreover, the Maine Experiment Station, in a circular⁵ which has come to our notice since the data in the present paper were obtained, advocates a similar use of the leg color in selecting hens for breeding.

The requirements of the "standard of perfection," which controls judging in the show room, as well as the common practice of poultry breeders, are opposed to a belief in any connection between laying and leg color. Woods,⁶ under the title, "Has Leg Color Value Indicating Layers?", discusses the subject and concludes:

Personally we believe that, as a practical guide in the selection of heavy layers or birds from which to breed heavy layers, the leg color, of itself, has no real value.

He further supports this conclusion by quotations from answers received from several prominent breeders to whom he had addressed a questionnaire on the subject.

So far as the writers are aware, no published data are available which show in how far the leg color may be of any value in selecting the laying hen, and such suggestions as have been made in this connection have confined themselves to a consideration of the legs alone. The results tabulated in the present paper show conclusively, it is believed, that a close connection does in fact exist between the yellow pigmentation in a hen and her previous egg-laying activity. They indicate further that the color of the beak is at least as distinctive as that of the legs heretofore alone considered in this connection, and that, in the Leghorns, the color of the ear-lobes is perhaps a better criterion of laying activity than either legs or beak and is more readily recorded.

The hens investigated were in the egg-laying contest located at Storrs, Conn. Pullets enter the contest November 1 and remain for one year. They are housed in pens of 10 birds each, are fed the same ration and so far as

⁵ Circular 499, Maine Agric. Exper. Station. This is listed as an abstract of Bulletin 232.

⁶ Woods, P. T., *Amer. Poultry Jour.*, p. 35, January, 1915.

possible are handled exactly alike.⁷ The influence of different environmental factors, therefore, can be largely neglected.

A preliminary test was made the middle of last September by taking from each of a number of different pens a pair of birds representing the extremes of yellow pigmentation and comparing their egg records. This test indicated that the extremely pale birds were laying and the extremely yellow ones were not. It indicated also that the ear-lobes were much more easily graded as to color and in addition were apparently more indicative of egg-laying activity than the beaks and legs. The ear-lobes of the American breeds are red like the comb and wattles and do not show yellow pigment. The ear-lobes of certain other breeds, like the Blue Andalusians, are white but apparently remain without any appearance of yellow ever taking place. The Leghorns, including Browns, Blacks, Buffs and Whites, show marked changes in the amount of yellow in their ear-lobes. White Leghorns, of which there were over 300 in the contest, were accordingly chosen for closer study.

Ear-lobe Color in White Leghorns.—Color can be conveniently measured quantitatively by means of the Milton Bradley color top, which, when spinning, acts as a color mixer. In matching ear-lobes, only yellow and white sectors have been used. The matching is not perfect, especially in the lower grades, since a certain amount of bluish tinge is often present. The amount of yellow, however, has probably been more accurately measured than if the other color components were considered. By the method used, it appears possible under proper illumination for one to repeat readings with a change of seldom more than 5 per cent. yellow above or below the mean observation.

Top readings were taken of the White Leghorns listed

⁷ Four pens of White Leghorns and four of White Rocks, belonging to the Experiment Station, had sour milk substituted for different ingredients of the normal ration, but, since they showed no apparent differences in color that could be attributed to the change in the feed, they were included in the tabulations.

TABLE I

AVERAGE EGG RECORDS FOR DIFFERENT AMOUNTS OF YELLOW IN EAR-LOBES
OF 312 WHITE LEGHORNS

Per Cent. Yellow	No. of Hens	July	Aug.	Sept.	Oct.	I Sept.	II Sept.	I Oct.	II Oct.	Year
5-10	7	23.1	21.3	19.7	15.3	9.9	9.9	9.29	6.00	197.1
11-15	36	21.8	22.1	18.2	14.2	9.4	8.8	8.14	6.03	187.9
16-20	40	22.2	20.7	16.9	11.7	8.8	8.2	7.50	4.17	184.3
21-25	16	19.8	21.4	16.4	8.1	8.1	8.3	5.56	2.50	164.3
26-30	20	19.5	18.9	10.3	3.2	5.5	4.8	2.75	0.45	148.5
31-35	31	18.0	17.7	5.5	0.5	3.5	2.1	0.45	0.00	139.1
36-40	33	19.7	17.3	6.1	0.2	4.2	1.9	0.15	0.00	139.6
41-45	41	18.2	16.2	4.9	0.2	3.4	1.6	0.22	0.00	134.2
46-50	39	18.0	15.6	4.0	0.2	2.6	1.4	0.18	0.05	138.2
51-55	30	18.4	16.1	3.6	0.1	2.9	0.7	0.00	0.07	137.8
56-60	13	14.8	10.7	2.4	0.0	2.2	0.2	0.00	0.00	124.7
61-65	4	14.5	8.8	1.3	0.3	0.3	1.0	0.25	0.00	100.8
66-70	1	3.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	70.0
71-75	1	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	83.0

TABLE II

PERCENTAGE OF HENS LAYING AND AVERAGE NUMBER OF DAYS SINCE LAYING
FOR DIFFERENT AMOUNTS OF YELLOW IN EAR-LOBES*White Leghorns*: total number of records, 932; total number of birds, 317

Per Cent. Yellow	5-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75
No. records.....	41	125	80	67	62	92	94	94	108	84	44	28	9	4
Av. days since laying.....	0.4	1.6	7.3	17.1	26.2	37.9	41.5	44.0	45.1	51.3	55.9	61.4	50.3	71.0
No. records = laying.....	36	98	44	17	3	0	1	0	2	0	0	0	0	0
Per cent. records =laying.....	87.8	78.4	55.0	25.4	04.8	0	01.0	0	01.9	0	0	0	0	0

in Tables I and II at three different periods. The first recording took from October 7 to October 14, the second from October 19 to 21 and the last was completed in one day, October 28. The top records were all made by the same one of us (*B*), except for 197 records on October 28. The men who took these records had already acquired familiarity with the method, and while their readings are not absolutely comparable with the others, they probably are sufficiently so to be included in Table II. The three top readings were taken on separate sheets and the egg records were investigated after the readings were all taken and the birds had left the contest. Personal bias that might have influenced the readings was thereby avoided.

Table I shows the percentage of yellow in the ear-lobes

of 312 birds according to the records of October 19–21, together with monthly and yearly egg records for the different color groups. The months of October and September are each divided into halves. It will be seen that in general as the percentage of yellow increases, the egg production falls off, and that the correlation is most marked during the periods nearest the time when the records were taken. A distinct though slight correlation seems to show as far back even as July and is strikingly evident in the yearly averages. For months before September and October, the correlation with color is probably an indirect one. It is generally only the best birds—those that make the large yearly records—that are laying in October. Therefore, any method that selects the laying birds at this season will select, at the same time, the birds laying above average throughout the year and consequently give high yearly totals. It will be observed that 30 per cent. seems to be a critical amount of yellow. Above this amount comes the sudden drop in egg production for the months of September and October and also above 30 per cent. yellow the yearly totals fall to between 130 and 140, with but slight change thereafter.

In Table II, the records at the three different readings have been used. A bird laying on the day of record or on a later day within the month is considered to be laying and credited with a zero. If she laid on the day before the record but not later, she is credited with one "day since laying," and in a similar way a longer period of inactivity in laying is indicated by a larger number of days since laying. With the exception of a few cases where this was not possible, three records were taken of each bird. Since October is the season of decreasing egg production, the majority of the birds increased their quantum of yellow and consequently most birds are listed in more than a single color grade. Beginning with the 41 records in the 5–10 per cent. color grade which show an average of only 0.4 day since laying, the number of days increases consistently with the amount of yellow in the ear-lobes, the irregularity at 70 per cent. being probably due to the

smallness of the numbers in this group. The percentage of records that indicate actual laying drops rapidly from 87.8 per cent. for 5-10 per cent. yellow to zero for grades of yellow above 30 per cent.^s The table shows that it is practically certain that a bird with an ear-lobe showing more than 30 per cent. yellow at the time of the records, is not in a laying condition.

TABLE III

AVERAGE EGG RECORDS FOR DIFFERENT GRADES OF YELLOW IN BEAKS AND LEGS OF 256 WHITE LEGHORNS
(P, M and Y are abbreviations for Pale, Medium and Yellow)

No. Birds	Beak	Legs	July	Aug.	Sept.	Oct.	I Sept.	II Sept.	I Oct.	II Oct.	Year
51	P	P	22.0	20.9	18.6	14.3	9.6	9.0	8.0	6.3	186.4
17	M	M	18.5	17.8	11.4	4.8	6.5	4.9	3.4	1.4	146.4
97	Y	Y	16.6	14.2	2.9	0.4	2.2	0.7	0.3	0.1	129.3
53	P	{ P 51 M 2 Y 0 }	22.1	21.0	18.3	14.0	9.4	8.8	7.9	6.1	185.3
43	M	{ P 25 M17 Y 1 }	20.1	20.6	13.7	5.7	7.4	6.3	4.2	1.5	164.6
160	Y	{ P 14 M49 Y 97 }	17.7	16.1	4.8	0.8	3.2	1.7	0.6	0.2	135.0
90	{ P 51 M25 Y 14 }	P	21.6	21.3	17.0	10.4	8.9	8.2	6.3	4.1	179.9
68	{ P 2 M17 Y 49 }	M	19.2	18.3	7.7	2.1	4.7	3.0	1.5	0.6	142.0
98	{ P 0 M 1 Y 97 }	Y	16.6	14.3	2.9	0.4	2.1	0.7	0.3	0.1	129.2
256	Averages of totals		19.0	17.8	9.1	4.3	5.2	3.9	2.7	1.6	150.4

Beak and Leg Color.—The beak and legs are more difficult to grade quantitatively than the ear-lobes. The color is less uniform in its distribution and has more of an orange hue, requiring the manipulation of at least one

^s The three cases of laying, among the 557 records in the grades above 30 per cent. yellow were for sporadic layers. The one in the 40 per cent. group laid October 18, but at no other time in October or September. This case may perhaps be an error in the egg record. One of the two in the 50 per cent. grade laid during October only upon the 2d, 4th and 25th, though she laid 18 eggs in September; the other laid during October only on the 16th and 19th and had no eggs to her credit in the second half of September.

extra color disk in taking the records. A rough grouping by inspection into the three grades, *pale*, *medium* and *yellow*, however, gives a striking corroboration of the results obtained by the more accurate records on the earlobes and is applicable to breeds in which ear-lobe yellow is not present. The grading was always done by the same one of us (W.) who has had some familiarity in handling poultry. Probably no two observers would entirely agree in recording the colors but the difficulty comes in delimiting the grade *medium*, and not in deciding between the extremes, *pale* and *yellow*. The color records were taken on October 31 and November 1 to 4, as the birds were being packed for shipment and their egg records were looked up for tabulation after they had left the contest.

Table III corresponds to Table I. In the first three rows are listed the birds that agree in beak and leg color. In the second three rows the birds are grouped according to their beak colors without regard to their leg colors, while in the last three rows they are grouped according to leg color alone.

Table IV corresponds to Table II. Since egg records for these birds stopped on October 31, a bird laying on October 29 is counted among the layers even if she failed to lay on the 31st—the day she left the contest.

It will be noted from Table III that, in the Leghorns at least, where the numbers are large enough to make comparisons significant, the beaks, considered alone, seem to form a slightly better criterion for picking out the hens with high records, while the legs alone are better in selecting the poorest layers. In the great majority of cases in all the breeds considered, if the beak and the legs fail to agree in color it is the beak that is listed the yellower. In October the hens are falling off in laying and in consequence increasing in yellow pigment. Apparently the earlobes and beak are more quickly responsive to this change. In only 97 out of 160 Leghorns for which the beak was listed as yellow had the legs reached a similar grading in color.

Of the 51 White Leghorns listed in Table III as pale in

both legs and beak, 31 had ear-lobe records of 20 per cent. or less yellow on October 28. These averaged a yearly total of 191.9 eggs. The 40 birds of those in Table III that on this date had 20 per cent. or less yellow in ear-lobes, irrespective of the color of other parts, averaged a yearly total of 189.4 eggs. It appears therefore that hens with a higher yearly average may be obtained by selecting those that are pale in all parts—ear-lobes and beak as well as in legs—than if only one of these parts is considered.

TABLE IV

PERCENTAGE OF BIRDS LAYING, AVERAGE NUMBER OF DAYS SINCE LAYING AND YEARLY TOTALS FOR DIFFERENT COLOR GRADES OF BEAKS AND LEGS

(P, M and Y are abbreviations for Pale, Medium and Yellow; the color of beak is written first, followed by color of legs)

White Leghorns (256 birds with yearly average of 150.4 eggs)

	P.P.	M.M.	Y.Y.	P.M.	P.Y.	M.P.	M.Y.	Y.P.	Y.M.
No. birds.....	51	17	97	2	0	25	1	14	49
Av. days since laying....	6.6	30.4	57.8	30.5	—	20.8	64.0	28.6	45.9
No. birds laying.....	32	2	1	0	—	3	0	1	1
Per cent. birds laying....	62.8	11.8	1.0	0.0	—	12.0	0.0	7.2	2.0
Yearly averages.....	186.4	146.4	129.3	150.5	—	178.7	122.0	158.4	139.9

White, Buff and Columbian Wyandottes (79 birds with yearly average of 144.8 eggs)

	P.P.	M.M.	Y.Y.	P.M.	P.Y.	M.P.	M.Y.	Y.P.	Y.M.
No. birds.....	28	13	24	1	0	4	0	0	9
Av. days since laying....	6.5	17.5	48.9	0	—	7	—	—	28.7
No. birds laying.....	16	5	0	1	—	2	—	—	1
Per cent. birds laying....	57.2	38.5	0.0	100.0	—	50.0	—	—	11.1
Yearly averages.....	178.3	130.7	108.4	194.0	—	161.5	—	—	145.6

Barred, White and Buff Plymouth Rocks (82 birds with yearly average of 142.4 eggs)

	P.P.	M.M.	Y.Y.	P.M.	P.Y.	M.P.	M.Y.	Y.P.	Y.M.
No. birds.....	27	15	22	3	1	5	2	3	4
Av. days since laying....	11.3	25.9	51.6	1.0	0.0	33.8	6.0	29.3	31.5
No. birds laying.....	15	3	0	2	1	0	1	1	3
Per cent. birds laying....	55.5	20.0	0.0	66.6	100.0	0.0	50.0	33.3	75.0
Yearly averages.....	153.7	149.7	123.0	163.7	204.0	138.8	117.5	130.7	140.0

Rhode Island Reds (114 birds with yearly average of 128.8 eggs)

	P.P.	M.M.	Y.Y.	P.M.	P.Y.	M.P.	M.Y.	Y.P.	Y.M.
No. birds.....	26	15	56	0	0	3	1	4	9
Av. days since laying....	11.3	15.8	50.4	—	—	19.0	38.0	18.3	41.2
No. birds laying.....	14	7	2	—	—	0	0	1	1
Per cent. birds laying....	53.9	46.7	3.6	—	—	0.0	0.0	2.5	1.1
Yearly averages.....	146.3	142.5	109.8	—	—	159.0	178.0	162.0	139.2

The method of grading beak and leg color may appear crude, but that it is capable of giving valuable evidence of previous laying activity is further shown by data kindly turned over to us by Professor C. A. Wheeler. On October 26, 1912, under his direction a series of measurements of 132 White Leghorns from the contest was taken by Mr. R. E. Jones. Among other records, the ear-lobes were graded as white, cream or yellow and the legs as pale or yellow, but no connection was worked out between the color and the egg records. These 132 birds we find to have a yearly average of 155.1 eggs. The 34 birds with pale legs averaged 188.9 eggs; the 98 with yellow legs, 143.5 eggs. The 33 birds with white lobes averaged 190.1, while the 99 with cream or yellow lobes averaged 143.5. The 21 birds that had both white ear-lobes and pale legs averaged exactly 200 eggs.

The data presented in the foregoing pages indicate a connection between the amount of yellow pigment showing in a hen and her previous laying activity. The most natural assumption is that laying removes yellow pigment with the yolks more rapidly than it can be replaced by the normal metabolism, and in consequence the ear-lobes, the beak and the legs become pale by this subtraction of pigment.

Environmental factors, other than laying, may be of more or less influence on yellow pigmentation. In fact, birds obviously sick have been observed to be pale although not in a laying condition. In the material investigated, however, variation in the laying activity seems to be the prime cause of the changes in yellow pigmentation in the domestic fowl.

The data of the present paper have been summarized in a preliminary report in *Science*, March 19, 1915. Photographs showing differences in yellow pigmentation in fowls are given in an article in the *Journal of Heredity*, April, 1915.

The change in yellow pigmentation is being further studied by a twice weekly top record of a flock of birds throughout the year.